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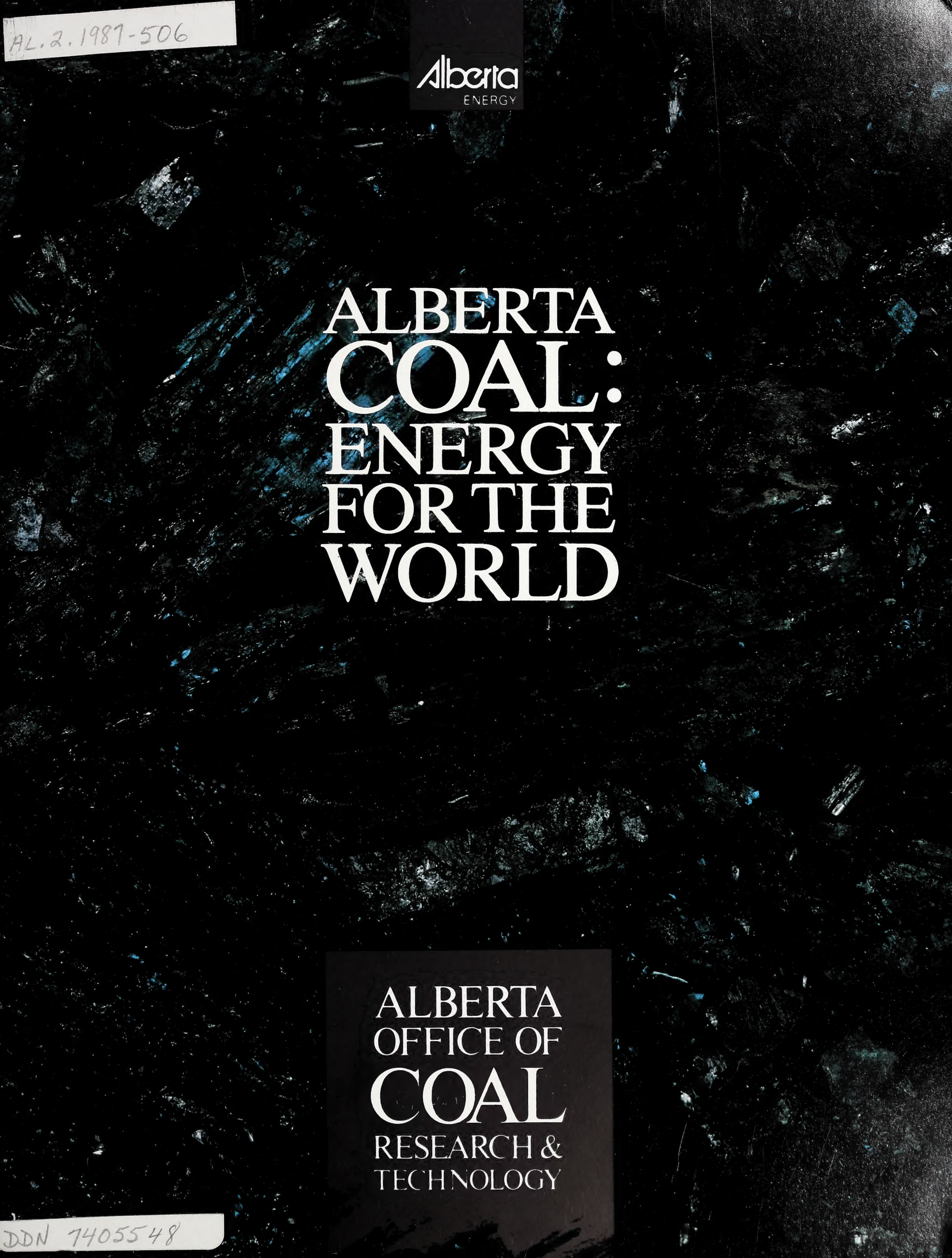

Alberta
ENERGY

ALBERTA COAL: ENERGY FOR THE WORLD

ALBERTA
OFFICE OF
COAL
RESEARCH &
TECHNOLOGY

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Medium volatile bituminous coking coal is extracted at this mine in the mountain region of Alberta.

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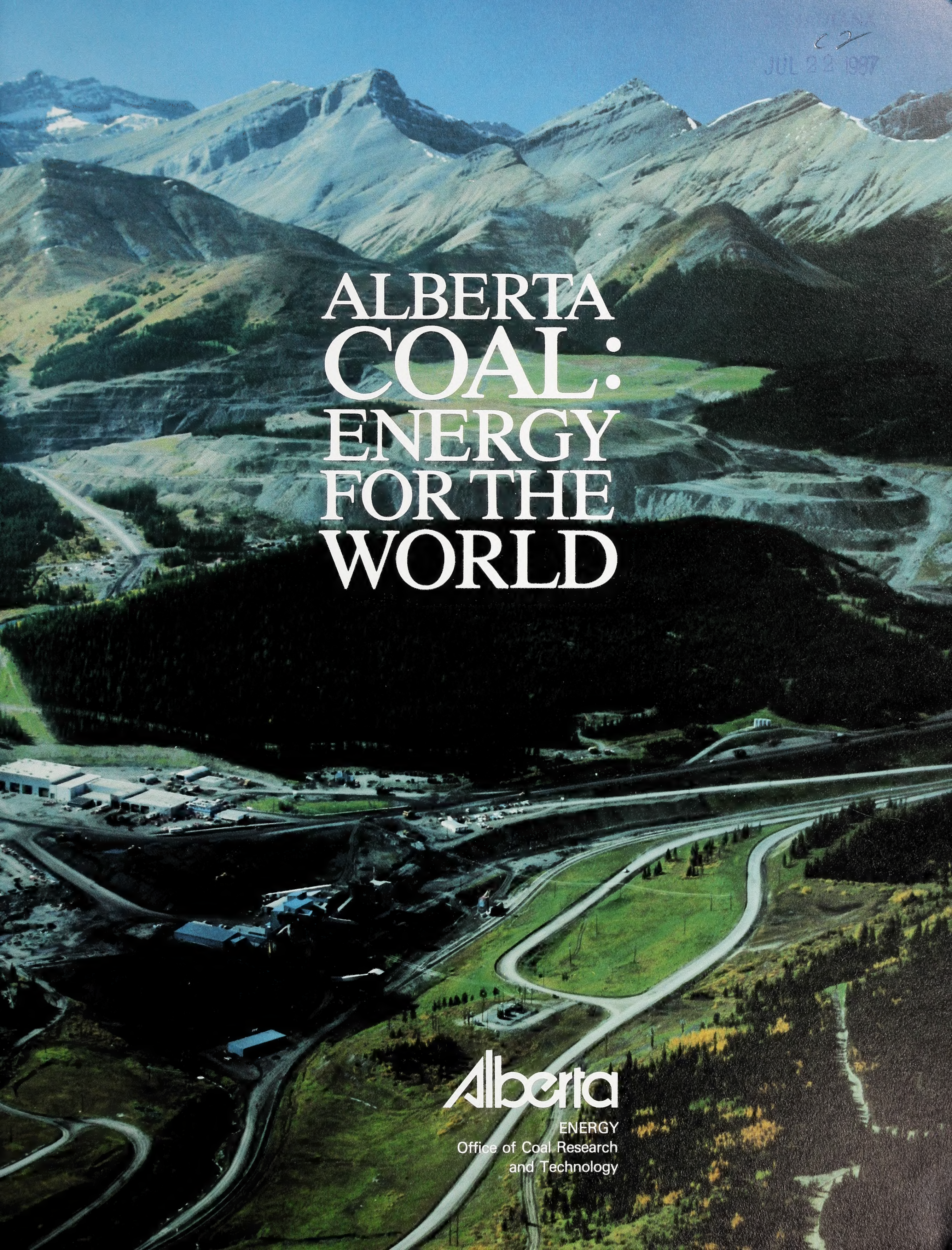

ALBERTA COAL: ENERGY FOR THE WORLD

Alberta
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Office of Coal Research
and Technology

Foreword

Seventy per cent of Canada's entire coal reserves are found in the province of Alberta. Coal-bearing formations underlie approximately 300 000 km² of the province, or about 46 per cent of its land area. Between 20 and 30 million tonnes of marketable coal are produced annually in Alberta, one quarter of which is exported to at least 11 countries. This makes Alberta the largest producer and the second largest exporter of coal in Canada.

In 1984, the Alberta Office of Coal Research and Technology was established by the Minister of Energy and Natural Resources to help Alberta's coal industry develop and implement new technologies that can be used to enhance the competitiveness of Alberta coals in international markets and establish new uses for Alberta coals.

The purpose of this publication is to inform coal users about Alberta's varied coal products and the ability of Alberta's coal industry to deliver products reliably and at competitive prices.

Alberta and the World

Alberta is one of 10 provinces and two territories that comprise the nation of Canada. It is located east of the province of British Columbia and is the westernmost of the three prairie provinces.

Alberta covers an area of 661 185 km², including 16 796 km² of inland water. Its topography varies from a forested region in the north, to rolling parkland dotted with timber groves in the central portion of the province, to relatively treeless prairie grassland in the south. Alberta's western boundary with British Columbia is marked by the spectacular Rocky Mountains. They are the principal attraction in Banff and Jasper national parks, which are located entirely within Alberta.

The province of Alberta is sparsely populated, containing about 2.4 million people or an average population density of 3.6 persons per km².

Alberta's population is classified as 77 per cent urban, with more than half the people residing in the two cities of Edmonton and Calgary.

Alberta is one of 10 provinces and two territories comprising Canada.

It is Canada's largest coal producer and second largest coal exporter.

Alberta's Energy Resources

Alberta is Canada's energy storehouse. Compared with the rest of Canada, Alberta's reserves of oil, natural gas and bitumen account for 90 per cent of the nation's total and Alberta contributes 67 per cent of Canada's total primary energy production.

Oil

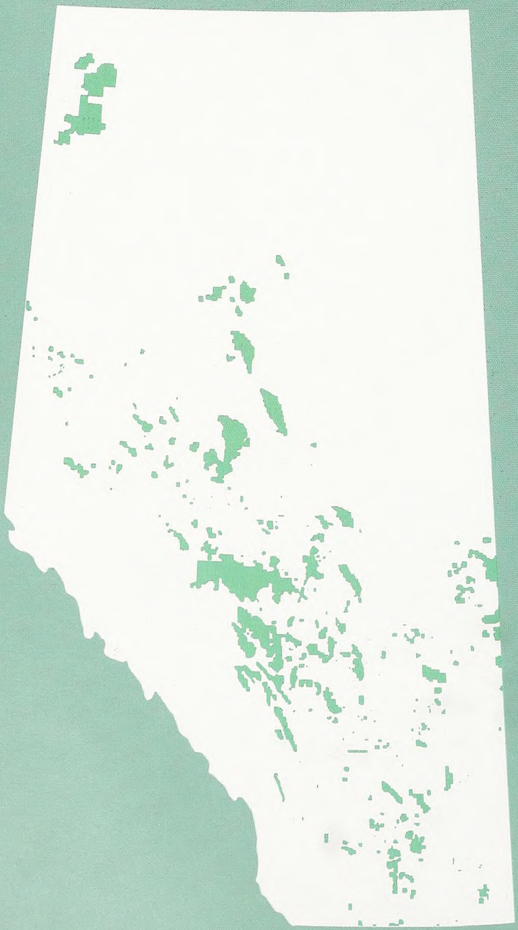
A major oil discovery at Leduc, Alberta in 1947 was the beginning of Alberta's modern oil industry. Currently, Alberta oil fields produce 71 per cent of Canada's conventional crude oil, and remaining established crude oil reserves represent about 78 per cent of Canada's total.

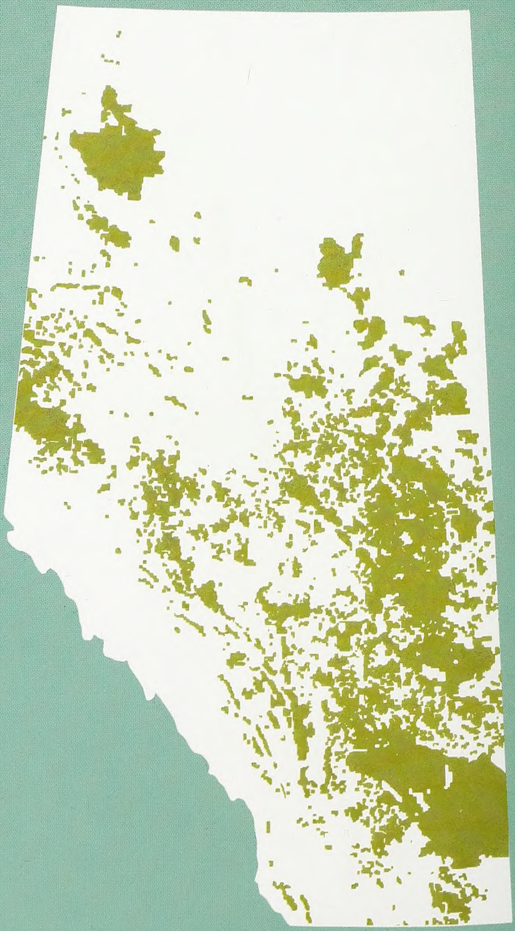
Natural Gas

Natural gas production began in Alberta in 1914; currently, Alberta supplies about 95 per cent of Canada's total production. Long-term reserves in Alberta represent about 86 per cent of Canada's total. Because the province has supplies beyond its own needs for at least the next 25 years, gas producers are continually striving to develop new markets outside the province for this resource.

Oil Sands and Heavy Oil

Oil sands underlying 77 000 km² of Alberta contain one of the world's largest



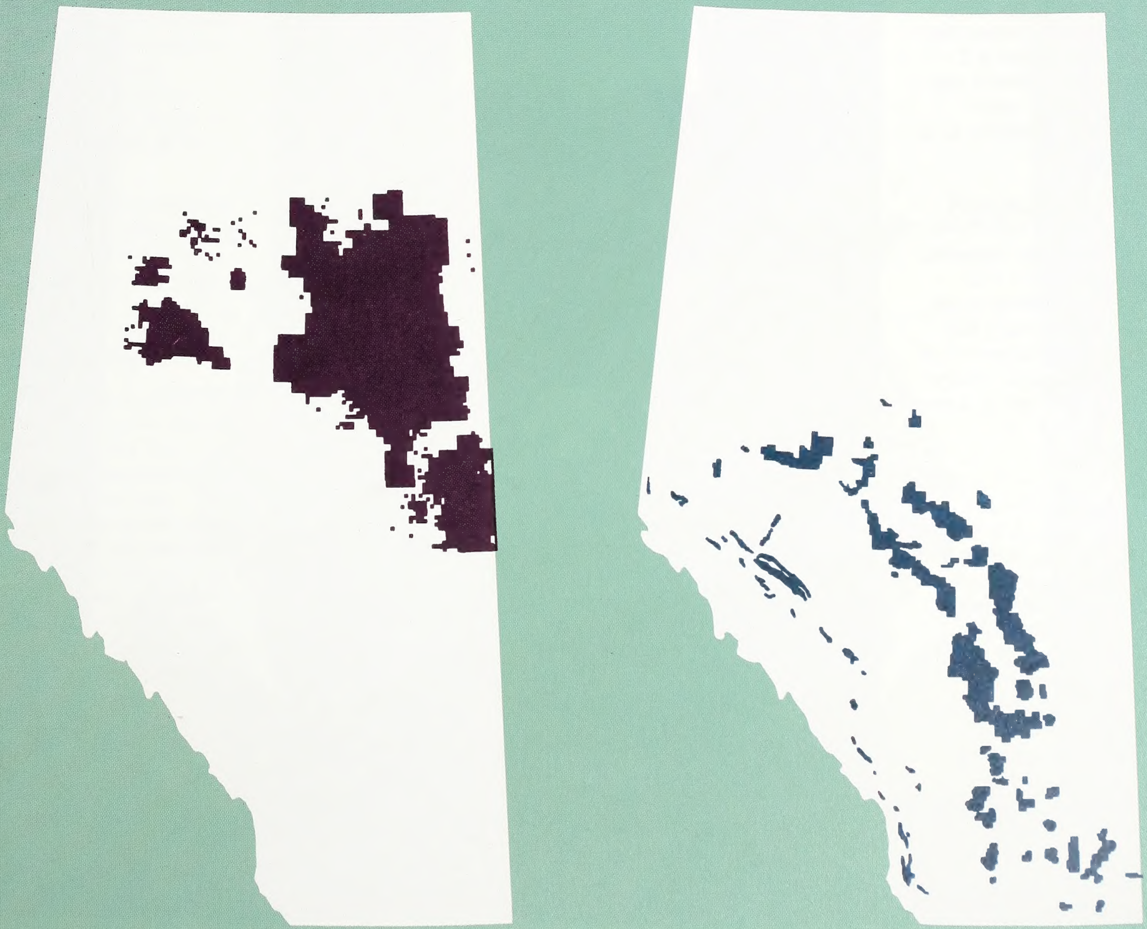


known reserves of recoverable oil. Since 1967, commercial-scale mining and processing plants have been recovering bitumen from oil sands and converting it into a synthetic crude oil. This makes Alberta the world's major supplier of petroleum products from oil sands. During the mid-1980s, another source of recoverable energy was tapped, as recovery of heavy oil began in the east-central region of the province. Although provincial reserves of oil, natural gas and oil sands are substantial, the magnitude of Alberta's coal resources is even larger. The energy they contain is nearly twice that of all other non-renewable energy sources combined.

Location of Alberta's Energy Resources

- 🟩 Oil Deposits
- 🟨 Gas Deposits
- 🟪 Oil Sands Deposits
- 🟦 Coal Deposits

Source:
Energy Resources Conservation Board



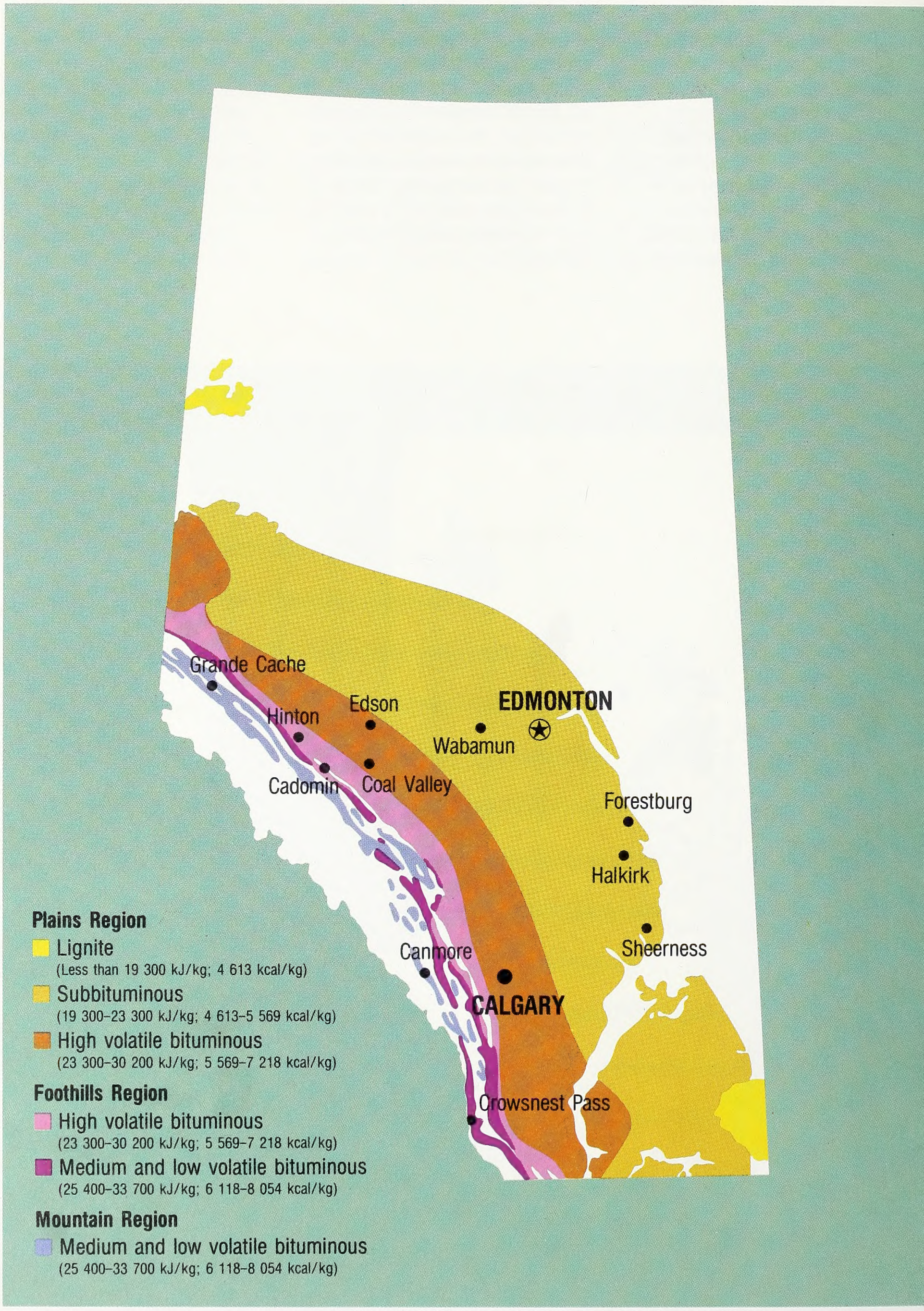
Alberta's Coal Resources and Reserves

Three Coal Regions

Alberta's coal reserves are distributed over three distinct physiographic areas, namely the mountains, the foothills and the plains. Alberta coals range in rank from subbituminous coals mined in the plains to high volatile bituminous thermal coal in the foothills and low and medium volatile bituminous coking coal mined in the mountains. Also, small quantities of lignite are found in the plains. Regardless of rank, Alberta coals are low in sulphur, typically 0.2 to 0.7 per cent, which is considerably less than in European or eastern U.S. coals. This makes Alberta coal particularly suitable where sulphur dioxide emissions are of special concern.

Long-Term Supply

Alberta's total coal resources are estimated to be 2 600 gigatonnes (a gigatonne is one billion tonnes), of which 800 gigatonnes are considered to be potentially recoverable, enough to last many centuries at present extraction rates. By far, subbituminous plains coals are present in the greatest quantities (790 gigatonnes potentially recoverable), enough to keep the province's existing coal-fired electric power plants supplied for 1 100 years. In addition, there are 10 gigatonnes of bituminous coking and steam coal in the mountains and foothills. With coal resources this large, long-term coal contracts can be supported without fear they will be curtailed because of provincial or national energy requirements.


Grande Cache
Edson
EDMONTON
Hinton
Wabamun
Cadomin
Coal Valley
Forestburg
Halkirk
Canmore
Sheerness
CALGARY
Crowsnest Pass
Plains Region
Lignite
(Less than 19 300 kJ/kg; 4 613 kcal/kg)
Subbituminous
(19 300–23 300 kJ/kg; 4 613–5 569 kcal/kg)
High volatile bituminous
(23 300–30 200 kJ/kg; 5 569–7 218 kcal/kg)
Foothills Region
High volatile bituminous
(23 300–30 200 kJ/kg; 5 569–7 218 kcal/kg)
Medium and low volatile bituminous
(25 400–33 700 kJ/kg; 6 118–8 054 kcal/kg)
Mountain Region
Medium and low volatile bituminous
(25 400–33 700 kJ/kg; 6 118–8 054 kcal/kg)

Alberta's Coal Geology

The coal-bearing strata of Alberta are confined to the southern half of the province. In the plains, coal-bearing strata dip gently toward the west, while in the foothills and mountains, strata are folded and faulted.

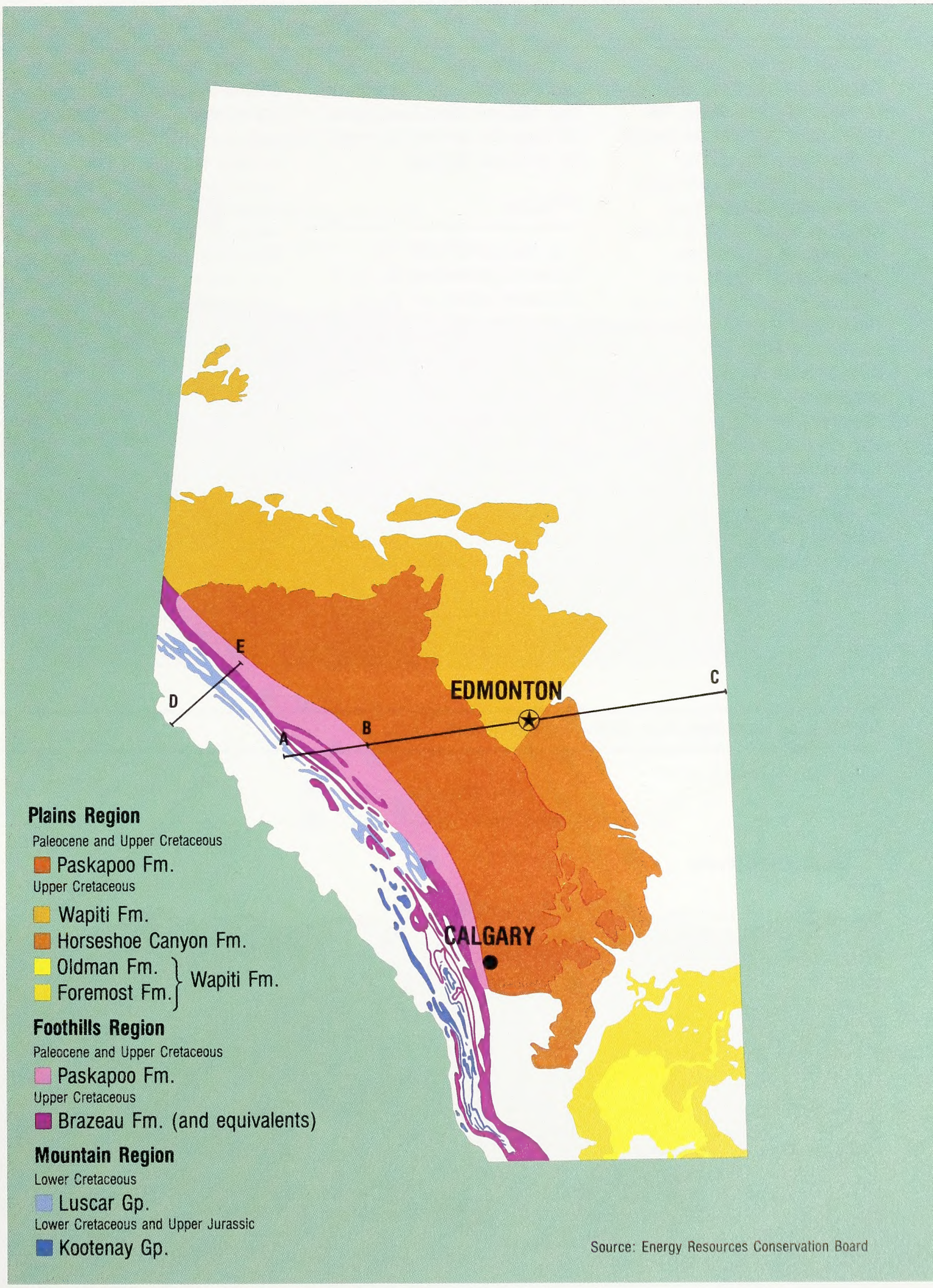
Mountains

Coal seams occur in Alberta's mountains in two stratigraphic intervals. In ascending order they are: (1) the Kootenay Group and (2) the Luscar Group.

Alberta's oldest coal-bearing strata are found in the Kootenay Group whose age transgresses the Jurassic-Cretaceous boundary. These strata are found at or near the surface in the southernmost part of the province.

The Kootenay Group contains from two to eight seams varying in thickness from 1 m to 10 m. However, as a result of folding and faulting, coal can often occur in deposits several times the normal seam thickness.

Lower Cretaceous, generally non-massive strata overlying the Nikinassin Formation (the Kootenay Group equivalent) in the central and northern mountain area are known as the Luscar Group. It contains coal seams ranging in number from two to nine, which are up to 13 m thick. Like the Kootenay coals, the seams may be thinned or thickened by tectonic forces.



Source: Energy Resources Conservation Board

Foothills

In the Coal Valley-Hinton basin of the outer foothills east of the Rocky Mountains, the main coal-bearing strata belong to the middle part of the Saunders Group of sediments and encompass the Upper Cretaceous and Tertiary strata. This interval includes the uppermost sediments of the Brazeau Formation with two or three commercially unimportant seams, the Entrance conglomerate (or an equivalent sandstone), which is a very useful marker bed in the basin, and the Coalspur Member with economically important coal seams. These seams correspond to the Ardley Coal Zone of the plains and are Tertiary in age. In the Coal Valley-Hinton area, coal is found in a number of seams. Usually two or three are of commercial significance in a specific locality. In some places, coal has been thickened up to 20 times the normal thickness by imbricate faulting.

Plains

In the plains, coals of economic interest are found in sediments which are Upper Cretaceous and Lower Tertiary in age. The coal-bearing strata are inclined at a low angle with a dip towards the west. Consequently, outcrops of younger strata occur farther to the west. Most of the coal is present in relatively thin zones, usually 25 to 100 m thick, within the formations. Major coal seams are present in the Foremost Formation and in the Oldman Formation in the southern plains. In the central area of the plains, coal seams are present in the Horseshoe Canyon Formation and in the Scollard Member of the Paskapoo Formation. The latter formation is Tertiary in age; the remainder are Upper Cretaceous sediments. Thick coal seams are also present in the Lower Cretaceous Mannville Group.

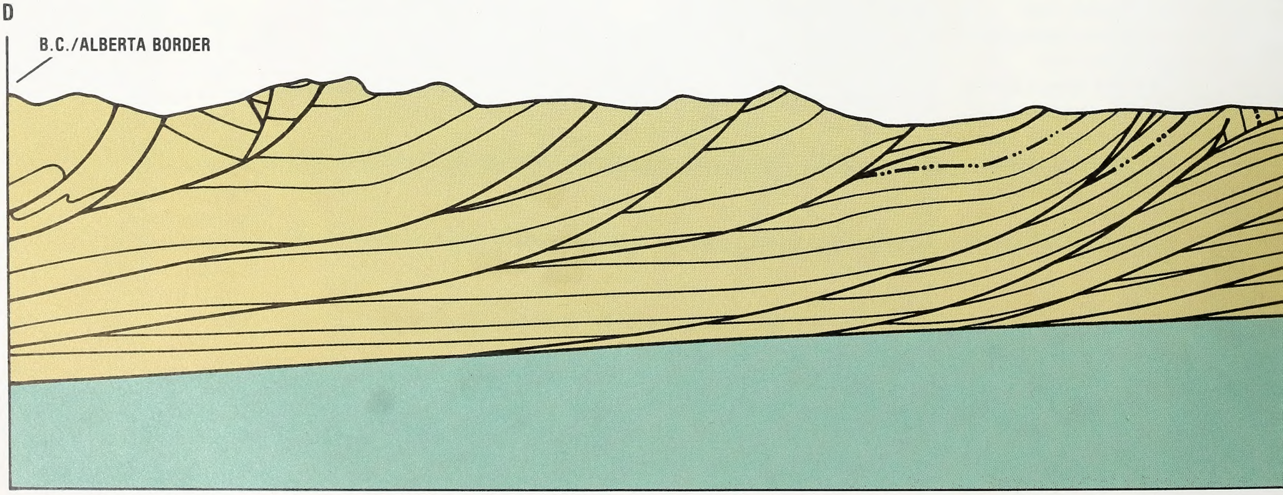
In the Oldman and Foremost Formations, cumulative coal thicknesses within the group range up to 6 m, with individual coal seams of up to 3 m.

In the Horseshoe Canyon Formation, areas of cumulative coal thickness up to 12 m occur, with individual coal seams up to 5 m thick.

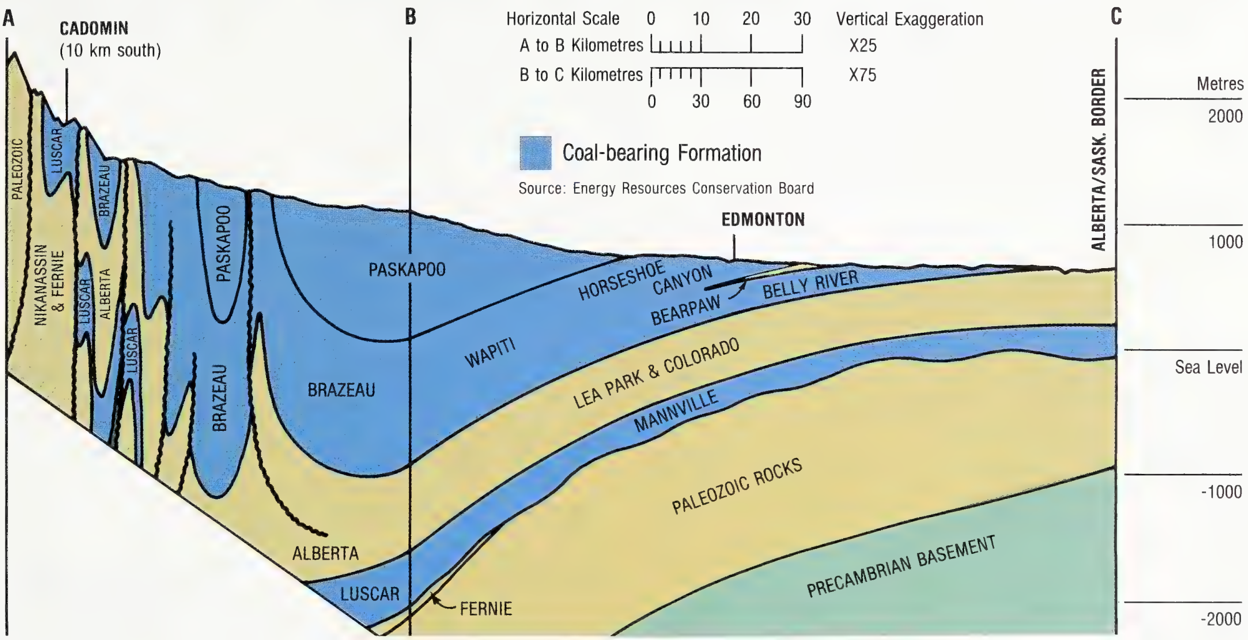
The Wapiti Formation occupies the north-central portion of the province and is the undifferentiated stratigraphic equivalent of the Foremost, Oldman and Horseshoe Canyon formations. Coal seams up to 3 m thick occur within this formation.

The Scollard Member of the Paskapoo Formation, the uppermost of the major coal-bearing units, contains both the thickest and the most continuous coal seams. Traditionally, these seams have been referred to as the "Ardley" coals. Coal zones with cumulative coal thickness up to 24 m and containing coal seams up to 5 m thick occur in this member.

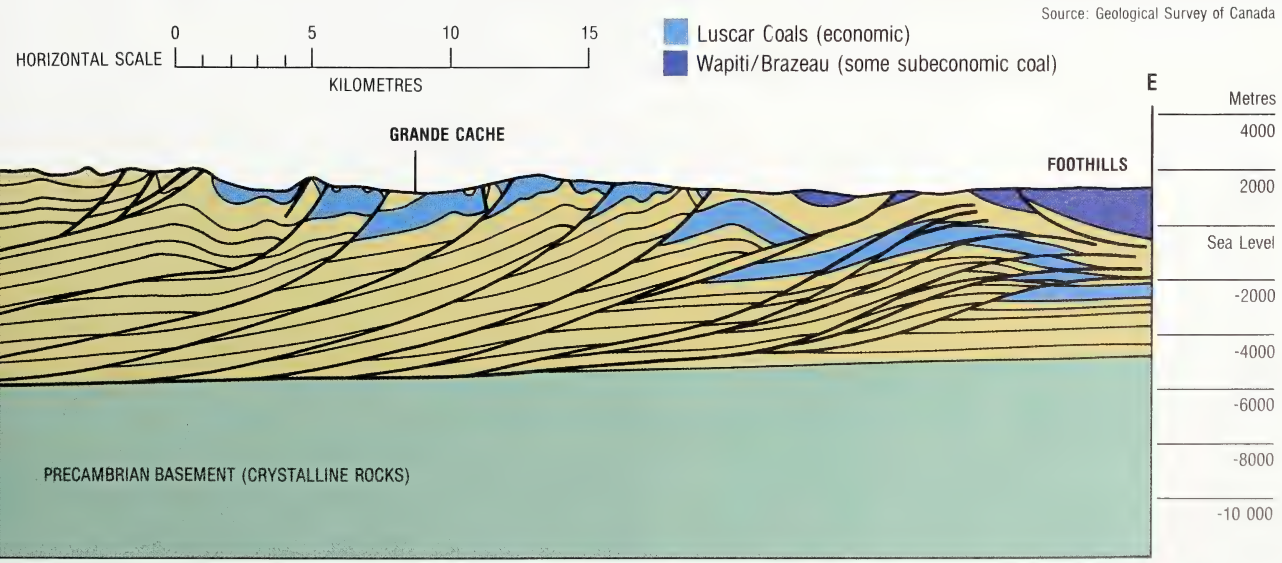
Coal-Bearing Formations Near Mount Robson/Grande Cache



Representative Cross-Section Showing Central Alberta's Coal-Bearing Formations



Source: Energy Resources Conservation Board



Source: Geological Survey of Canada

Economic Aspects

Mountains

Mountain coals vary in rank depending upon the region and stratigraphic level.

In the Kootenay Group of sediments in southwestern Alberta, the highest coal rank occurs in the Canmore area where semi-anthracite is found. Elsewhere, the rank varies from low to medium volatile coking coal with a Free Swelling Index (FSI) of 6-7 and sulphur content in the range of 0.45-0.6 per cent. There are no coal mines in this formation at present. However, exploitation of these coals by extensive underground, as well as surface mines, occurred in the past in the Crowsnest Pass and Canmore areas, and in a few other less significant locations.

In the central and northern foothills, the Luscar Group coal seams are principally low to medium volatile coking coals with FSI of 6-9. Sulphur content varies from 0.35-0.4 per cent. In general, the coal seams are thicker and better developed in the northern part of the area. Currently, coking coal is produced and exported from the intensely folded 12 m-thick Jewel seam in the Cadomin-Luscar Coal Field.

The producing coal mining companies are Cardinal River Coal Ltd. and Gregg River Resources Ltd. Excellent coking coal is also produced from the Smoky River Coal Field, where seams 4, 10 and 11, ranging in thickness from 2 m to 8 m are mined by Smoky River Coal Limited. The Luscar coal seams are severely folded in the Cadomin-Luscar Coal Field. At Cardinal River and Gregg River, the anticlines are generally eroded and the open pit mines are being worked along synclinal limbs. The Smoky River Coal Field is located in four major thrust sheets. Folds are of the chevron variety, where coal is tectonically thickened up to two times in the hinges. Another exploration target is coal thickened by imbricate faulting. The coal can be thickened up to three times its normal thickness, which results in very favorable stripping ratios.

Foothills

The Coalspur coals of the foothills are principally high volatile bituminous ''C'' thermal coal. Sulphur content is 0.2-0.3 per cent.

These coal seams are being mined by Luscar Ltd. in the Coal Valley vicinity by open pit methods, and by Obed Mountain Coal Company Limited, near Hinton, by strip mining methods. At least four other locations are under serious consideration for new mine development.

Plains

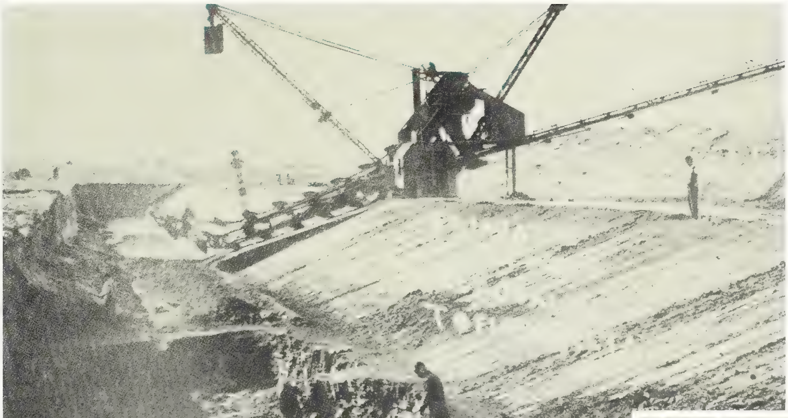
Coals within the plains area of Alberta range in rank from subbituminous ''C'' to high volatile bituminous ''C''. Sulphur content is normally low, ranging from 0.32-0.66 per cent. Most of the area is covered by a mantle of glacial drift, usually varying from a few metres to 20 m in thickness.

Plains coals are exploited by a number of large strip mines serving thermoelectric generating stations (five, with one under construction). Additionally, a number of very small strip mines serve the local trade. There are no underground mines in the plains area. The coal seams present in the Mannville Group have not been regarded as a potential economic resource because of their depth. In the long term, they may be exploited by in situ gasification or even deep mining.

The possibility of enhancing the economic potential of plains coals, through product upgrading to exportable quality, is being actively pursued, as is the conversion of these coals into liquid transportation fuels.

Alberta's Coal Industry

Coal mining in Alberta began in the late 1700s when a Hudson's Bay Company explorer and trader, Peter Fidler, sighted coal along Rosebud Creek near Drumheller, in southern Alberta. Coal was easily accessible and abundant in the southern Alberta plains area. In north-central Alberta, it had a fairly wide local use in the Fort Edmonton area as early as the 1840s.



The First 70 Years

The first recorded coal mine was begun in 1874 on the banks of the Oldman River below Lethbridge. This was followed during the 1880s by the opening of mines in the Canmore, Medicine Hat and Edmonton areas. The first mining method was underground room-and-pillar, but after 1910, strip mining in the plains area augmented these operations and usually involved the removal of overburden by horse-drawn scrapers.

During these early years, fuel required for growing towns and rural communities caused a gradual increase in the demand for coal, and progressively larger quantities of coal were required by steam locomotives. By 1914, Alberta collieries directly employed over 8 000 men and women and produced over three million tonnes of raw coal each year. Most mine operations consisted of very small workings, mostly designed to serve local markets, and were often operated by farmers as part-time ventures during the winter season. In 1923, for example, 293 of 362 mines produced an average of less than 1 000 tonnes each, and accounted for only 4.7 per cent of total production. Many mines had extremely short lives and were often opened and abandoned in less than a year. Nevertheless, by the mid-1920s, a distinctive Alberta coal mining industry had come into existence. During the 1920s and '30s, Alberta coal was used primarily in steam locomotives and it was sold locally for domestic heating purposes.

At one of Alberta's newest mines, bituminous coal is mined and loaded by a continuous surface mining machine.

Coal mining circa 1920 at Tofield, Alberta, in the plains area.

The Impact of Oil and Natural Gas

Coal use continued in this manner until 1947 when a major oil discovery was made at Leduc, Alberta. This led to a marked decline in the demand for coal, not only because railways switched to diesel fuel, but also because associated discoveries of natural gas eventually made it possible for this fuel to become widely used for residential, commercial and industrial purposes.

The Resurgence of Coal

The first oil shock in 1973 reversed this trend and resulted in new uses for Alberta coal. Several years earlier, demand for coking coal in Japan led to the development of two mines in the mountains and when the international price of crude oil rose rapidly in the 1970s, coal demand for purposes other than steel-making provided opportunities to develop two bituminous steam coal mines in the foothills. Between 1971 and the present, total sales of Alberta coals increased steadily. During this period, overseas demand for coking coal increased, resulting in the development of an additional coking coal mine in the central mountains. Meanwhile, Alberta's electricity generators began consuming significantly larger quantities of subbituminous coal. Today, the major market for Alberta subbituminous coal is for the generation of electricity within the province, although small shipments are made to the other prairie provinces. Also, Ontario Hydro (the second largest producer of electricity in Canada) began to purchase bituminous steam coal from Alberta during the late 1970s, as did Japan and other countries.

Low volatile bituminous coking coal is mined at the Smoky River Mine in the mountain region.

Alberta's Modern Coal Industry

Two Distinct Segments

The development of Alberta's modern coal industry occurred during the last quarter century. The industry can be characterized as two distinct coal production activities operating separately: one segment supplies subbituminous coal to mine-mouth electricity generating stations and another segment produces bituminous coals for central Canadian and overseas markets.

All mining activity in the province is based on surface operations with one exception, where a combination of surface and underground mining is carried out at a mountain location.

Typical Operations

In a typical foothills or mountain coal mine, the overburden is drilled with large drill rigs, and blasted. Large shovels with a capacity of up to 23 m³ load the broken rock on trucks of up to 150 tonnes capacity for disposal in waste dumps. The exposed coal is loaded by electric shovels and front end loaders on to trucks for haulage to a central coal cleaning plant. At one of Alberta's newest mines, bituminous coal is mined by a continuous loading machine capable of digging and loading 1 500 tonnes an hour, using 108 tonne capacity dump trucks to haul the coal to the preparation plant.

On the plains of Alberta, strip mining is used exclusively. Gently dipping coal seams, encased in soft sediments and glacial tills, can be exposed by side casting operations using drag lines.

There are 12 mines in the plains, six of which supply their production of subbituminous coal to nearby electric power generating stations. Included in this latter group is the Highvale Mine. This strip mine is the largest coal mine in Canada, producing 12 million tonnes a year. At the other end of the scale, several small plains mines produce coal for the local domestic heating market.

A dragline, using a 23 cubic metre bucket, strips overburden to allow removal of sub-bituminous coal at the Montgomery Mine in the plains region.

Production Capacity

Present capacity in the province would permit the production of 17 million tonnes of subbituminous coal, six million tonnes of bituminous steam coal and seven million tonnes of coking coal each year. Additionally, detailed exploration has been completed on a number of coal properties in the mountains and foothills, and production capacity from these regions can readily be doubled, as opportunities develop.

Subbituminous is the only coal that is currently consumed in the province; this situation is not likely to change in the near future.

Typical properties of coals currently mined in Alberta are summarized in the table on the following page.

Typical Properties of Coals Currently Mined in Alberta

	Coal A	Coal B	Coal C	Coal D	Coal E	Coal F	Coal G	Coal H	Coal I
A. Classification									
a) International	332	433							
b) ASTM No.		D-388							
c) ASTM Description	Low Vol. Bit.	Med. Vol. Bit.	Med. Vol. Bit.	High Vol. C. Bit.	High Vol. C. Bit.	High Vol. C. Bit.	Subbit C.	Subbit C.	Subbit B.
B. Proximate Analysis (as received)									
a) Total Moisture	6	7	8	9-10	9-10	12-13	17-18	23-25	18-19
b) Ash	7-8	9-10	9-10	9-10	9-10	12-13	8-10	9-11	12-14
c) Volatile Matter	17.5-20	21-25	22-25	33-35	35-37	33-35	29-31	30-32	28-30
d) Fixed Carbon	75	62-64	62-64	46-48	44-46	41-43	43-45	36-38	40-42
e) Sulphur	0.45	0.35	0.4	0.2-0.3	0.2	0.5	0.3	0.3	0.6
f) Fuel Ratio	3.6-3.9	2.7-3.0	2.7-2.9	1.3-1.5	1.2-1.3	1.2-1.3	1.5-2.0	1.1-1.25	1.3-1.5
C. Ultimate Analysis									
a) Carbon	84.4	74.7	75.5	63.0	64.4	76.8	67.6	73.2	65.8
b) Hydrogen	4.3	4.7	4.3	4.5	4.0	5.2	4.1	4.8	4.5
c) Ash	7.3	9.5	9.5	9.5	9.5			9.0	13.8
d) Sulphur	0.4	0.4	0.3	0.25	0.2	0.65	0.3	0.6	0.7
e) Nitrogen	1.3	1.1	1.2	0.9	0.8	1.6	0.9	1.3	1.3
f) Oxygen	2.3	5.0	3.3	12.0	12.9	15.7	17.3	16.1	13.4
D. Physical Properties									
a) Hardgrove Grindability Index	91	84-95	85-87	41-54	41	43	43	41	46
E. Thermal Properties									
a) Calorific Value (Kcal/kg)	7785	7150	7275	6000	6100	5600	5110	4645	4940
b) Ash Analysis									
SiO_2	55.5	54.8	61.7	46.3	45.9	63.3		35.7	51.0
Al_2O_3	28.1	23.9	30.8	16.7	16.2	19.4		30.0	10.7
Fe_2O_3	5.1	6.4	2.0	6.9	4.2	3.95		6.9	16.4
TiO_2	1.1			0.4	0.4	0.57		0.4	0.6
P_2O_5	1.3			0.1	0.1	0.14		1.0	0.8
CaO	3.7	6.9	1.4	19.7	22.4	5.9		17.9	7.7
MgO	0.3	2.0	0.5	0.07	0.1	1.2		2.8	1.5
SO_3	2.5	2.3	0.3	6.2	3.1	4.3		13.7	3.6
Na_2O	0.4	1.0	1.5	1.0	1.2	0.14		1.8	5.2
K_2O	0.5	0.7	0.6	0.7	1.2	0.52		0.4	1.1
Unidentified									
c) Ash Fusibility				oxid. red.		oxid. red.			
Initial Deformation Temp.	1350°C			1225°C 1200°C	1200°C	1260°C 1250°C	1315°C	1190°C	1275°C
Softening Temp., Spherical	1482°C +			1295°C 1300°C		1310°C 1300°C			
Softening Temp., Hemispherical	1482°C +			1345°C 1340°C		1350°C 1330°C			
Fluid Temp.	1482°C +			1385°C 1450°C		1400°C 1385°C			
d) Ash Fouling $\frac{CaO + MgO}{Fe_2O_3}$	0.78			1.5-1.8		1.8			
F. Coking Properties									
a) Coking Indices									
- Free Swelling Index (FSI)	7-8	5-7							
b) Gieseler Plastomer									
- initial softening	464°C	405°C							
- maximum fluidity	1.9	260ddm							
- max. fluidity temp.	478°C	460°C							
- final temp.	488°C	495°C							

Source: Alberta Office of Coal Research and Technology

Alberta's Export Experience

Total deliveries of Alberta coals have increased steadily since 1976. Approximately 22 per cent of production is sold offshore and in the U.S.A., while some sales are made within Canada to customers in other provinces.

Transportation

Alberta's coal exports require a modern and efficient railroad system to move coal a distance of about 1 000 km to the Pacific coast, and even farther to central Canada. Both major railroads continually upgrade their lines, which has resulted in one of the world's most efficient transportation systems. Typically, a 100-car coal train, called a "unit train," carries 10 000 tonnes to a west coast marine terminal and returns to complete the cycle in approximately 44 hours.

Although these trains must cross several mountain ranges to reach the coast, they generally travel through the relatively easy grades of the Yellowhead Pass to Kamloops, B.C. and from there by way of the Fraser Canyon to Vancouver.

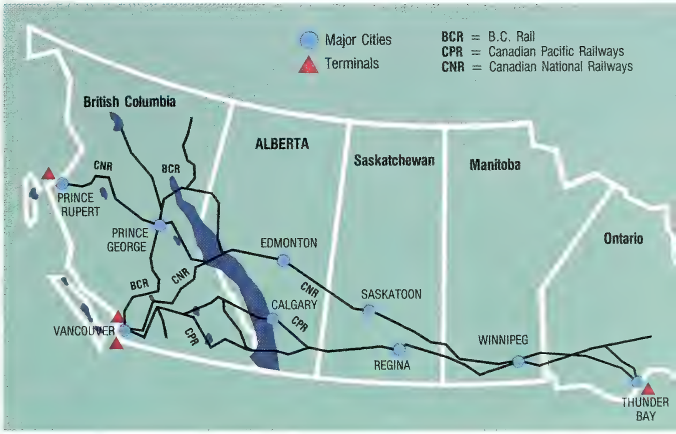
Even though Alberta mines are from 1 000 to 1 100 km inland, the rail haul distance for some of them is shorter than for mines located in southeastern and northeastern British Columbia.

Alberta coal destined for central Canada is transported by unit train to a marine terminal at Thunder Bay, a distance of 2 000 km. From there, it is carried by Great Lakes vessels to markets in southern Ontario.

Marine Terminals

Alberta coals are shipped overseas from three marine terminal facilities, two of which are located in or near Vancouver while the third is located north of Vancouver at Prince Rupert. The total coal capacity of all three terminals is approximately 40 million tonnes a year.

Once coal is loaded aboard oceangoing ships, the cost to move it from Canada's west coast to Pacific Rim customers is less than Australian ocean freight costs and can be as low as half the cost to ship coal from the U.S.A.



Alberta and British Columbia coals are hauled by rail to west coast terminals.

Alberta coal, stockpiled at Westshore Terminals south of Vancouver, is loaded on ships bound for overseas customers.

Unit trains operated by Canadian National Railways haul 10 000 tonnes of coal per trip from Alberta to west coast terminals.

Government Support

There are three levels of government in Canada: federal, which governs the country as a whole, provincial, for the self-governing of each province, and municipal. Each level has distinct areas of jurisdiction, as provided in the Canadian constitution. For example, all minerals and royalties derived from the sale of minerals belong to the provincial, rather than the federal government.

The Gregg River Mine is the world's first joint venture between the Japanese steel industry and a coal producer.

Wash plant at Obed Mountain Coal Mine in the foothills region.

Government-Industry Co-operation

In 1976, the provincial government produced ''A Coal Development Policy for Alberta,'' which placed certain restrictions on coal mining activities, while emphasizing that the coal industry should be encouraged to take appropriate development initiatives. Government assistance will be provided to industry in a number of areas; technology development is one, infrastructure development is another. For example, the Alberta government prefers to encourage the growth and improvement of existing towns and facilities to serve new mines rather than the creation of new town sites and associated facilities. Also, the government will upgrade roads within its jurisdiction, while relying on developers and municipal authorities to provide local highway access to mine projects.

Mineral Royalties

Although Alberta coal companies are required to pay normal municipal taxes, they are not taxed by the provincial government. Because 85 per cent of all mineral rights are held by the Alberta government, resource industries that extract government-owned minerals are required to pay royalties, which vary according to the profitability of the business venture. The amount paid by the coal industry is minimal at present; currently the combined royalty and taxation load on Alberta's coal mining companies is among the lowest anywhere. Revenues derived from all forms of resource extraction make it possible for Alberta to have a stable economy. It also has a political environment that encourages private enterprise and foreign investment. For these reasons, Alberta is the only Canadian province that does not have a sales tax and it has among the lowest corporate and personal income taxes in Canada. Also, Alberta does not impose any form of inheritance tax.

The government, however, does not become involved in specific negotiations between individual coal producers and their customers. Marketing and sales remain the sole responsibility of coal mining companies.

Neither the Alberta government nor the federal government in Ottawa controls the volume of coal exported to other nations. While both governments stress that Albertan and Canadian needs must be met first, it is recognized that Alberta's surplus of coal allows industry ample opportunity to develop offshore markets. Because of this surplus of both steam and coking coal, the Alberta government encourages foreign investment in coal developments.

Government Departments

Two provincial government departments provide assistance to the coal industry. The Department of Energy oversees the province's resources, while the Economic Development department helps to stimulate economic diversification and growth in the private sector.

Added support for the coal industry is provided by the Alberta Coal Development Advisor, who was appointed by the Minister of Energy and Natural Resources (now Energy) in December 1985.

Research Fund

Beginning in 1976, the Alberta and federal governments established the Alberta/Canada Energy Resources Research Fund to encourage industry, academic institutions and research organizations to find ways to better use Alberta's energy resources, including energy conservation measures, and to explore the potential of appropriate alternative energy systems. From these efforts grew a recognition that initiatives associated with coal mining, transportation and product improvements deserved special attention. This resulted in the release of an Alberta Coal Research Strategic Plan in November 1983, following which the Alberta Office of Coal Research and Technology was established by the Minister of Energy and Natural Resources (now Energy) in January 1984.

Office of Coal Research and Technology

The primary focus of the Alberta Office of Coal Research and Technology is to encourage Alberta's coal producers to identify, investigate and develop those technologies that are likely to be commercially important during the next five to 10 years and will enhance the competitiveness of Alberta coals in international markets, minimize environmental impacts during coal production and utilization, and result in new uses for Alberta coals. The Alberta Office of Coal Research and Technology is co-funding with industry several dozen projects in specific areas such as coal upgrading, combustion, gasification, liquefaction and transportation.

The Office believes that international collaboration in coal-related research and development is important and that the early participation by coal producers and consumers in the development of coal technology is essential to achieving its goals.

New Research Centre

In 1984, Canada's newest coal research centre opened in Devon, Alberta. It houses approximately 120 researchers who are working on a broad spectrum of problems ranging from coal exploration and mining to the conversion of coal to liquid fuels. So far, their expertise in coal liquefaction has been partly responsible for the establishment of a firm that hopes to build a commercial-scale liquefaction plant in Alberta.

Major research efforts are now underway on a sizeable scale to make Alberta coals more prominent and in greater demand around the world. They emphasize the belief that industry and government must be at the forefront of technology developments if Alberta coal is to become more prominent in the international coal business.

Environmental Protection and Conservation

Through the Department of Environment and the Energy Resources Conservation Board (ERCB, an agency of the Alberta government), mines and other resource developments in Alberta are licensed and controlled to eliminate wasteful practices, to enforce conservation measures and to balance the effect of mining activities on the environment. Since the early years of Alberta's energy industry, the ERCB has been attempting to maintain a reasonable balance between maximum recovery of coal resources and economical costs of production. One of the conditions attached to coal mining licences in Alberta is the requirement that all surface mines be reclaimed to standards established by the government. In this manner, companies are encouraged to integrate reclamation requirements with mining plans to achieve maximum levels of efficiency. A joint industry/government reclamation research program supported by the Alberta Department of Environment has been established, which is one of the best of its kind in the world. It has contributed to the restoration of many former mine sites to their natural state or enabled some to be converted into productive agricultural land.

At the Vesta Mine in the plains region, crops are grown on portions of the mine site that have been reclaimed.

Future Development and Opportunities

The Alberta Coal Research Strategic Plan was prepared to guide the development and application of technologies related to coal exploration, recovery, beneficiation, transportation, storage and utilization.

The strategy provides a framework within which specific research and development activities are carried out co-operatively by the coal industry, the Alberta government and the scientific and technical community. These research initiatives are addressing certain constraints which currently limit the contribution that coal makes to Alberta's economy.

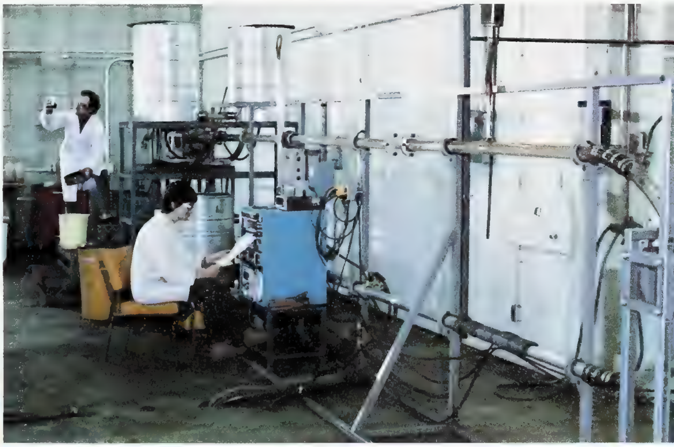
Transportation

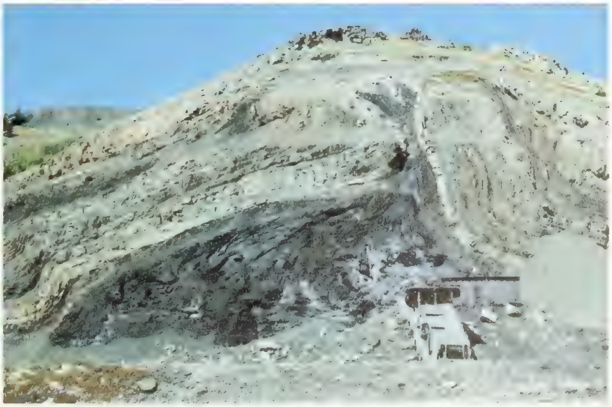
One such constraint is caused by the long distances over which bituminous coal from Alberta's mines must be hauled to markets. This results in relatively high transportation costs that account for 35 per cent of all the costs incurred in mining, cleaning and delivering Alberta coal to west coast ports. While attempts are being made to lower rail transportation costs, other transportation options are being investigated to assess their potential in reducing haulage costs. The technical feasibility of transporting coal slurries to the west coast by pipeline was demonstrated in a 1980 study.

It was followed by an examination in 1984, using pilot-scale pipelines, of the economies of transporting coal in a variety of slurry configurations. The prospect of using existing oil pipelines to move coal slurries is being examined and investigations of pipeline technology in general are continuing.

Exploration

To minimize mining costs while extracting coals of desired quality, Alberta's mine operators need the best information available about the location and definition of coal deposits. In their search for exploration methods that are both precise and inexpensive, mining firms are going beyond the common methods of surface seismic measurements combined with drilling of exploratory holes. Research projects are evaluating such techniques as reflection and refraction seismology, direct current resistivity and electromagnetic conduction, for possible application to short-, medium- and long-term mine planning.





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Researchers have investigated the feasibility of using pipelines to transport coal in a variety of slurry configurations. Here, slurries of agglomerated coal are studied at Alberta Research Council.

^
Alberta researchers are trying various exploration techniques to locate coal, which is sometimes found in complex geological settings such as in the hinge of an anticline, as shown here in the mountain region.

<
Canada's newest coal research centre opened in 1984 in Alberta.

Agglomerated coals, which are spherical, stable and low in ash and moisture, were produced by mixing coal and bitumen or heavy oil in a water slurry within a pipeline.

Mining

To remain competitive in the future, Alberta's coal industry must take the lead in developing and applying technologies which can lower the cost of coal mining without creating greater safety risks for workers.

Because studies suggest that mining conditions in Alberta will remain relatively unchanged until beyond the turn of the century, mining research studies have begun to focus on methods to make the best use of present surface mining techniques. They include investigations of coal and overburden properties, equipment development and automation of mining methods.

Coal Preparation and Upgrading

One of the priorities of Alberta's research efforts is to produce upgraded coals having less moisture, fewer inerts and an enhanced energy content.

In support of these aims, studies have been made of coals varying in rank from bituminous to lignite to establish relationships between coal rank and thermal drying characteristics. Also, experiments have been conducted to minimize the amount of moisture that is readsorbed on to thermally dried coals. One process, which prevents readsorption of moisture and reoxidation, shows some promise as a method of producing coals that are well suited for markets in Europe, the Pacific Rim countries and throughout the world.

At the same time that efforts are underway to upgrade bituminous coals, several research studies aimed at upgrading subbituminous coals have been initiated to take advantage of the substantial established in-place resources of this coal rank (approximately 45 gigatonnes), which are relatively accessible and easily mined at low cost in the plains. One promising technique to upgrade subbituminous coals involves agglomeration of finely divided coal particles with oil in a water slurry. The end result is a product that contains less moisture and fewer inorganic impurities than the parent coal. As a side benefit, the agglomeration reaction can take place in a pipeline, thus combining an upgrading step and a mode of transportation in one process. To assist researchers in studies that involve subbituminous coals, the Alberta Research Council has done in-depth studies of plains coal properties, summarized in the accompanying table and charts. Similar studies are proposed for coals from the foothills.

Properties of Plains Coals

		Scollard Member			Horseshoe Canyon Formation		
		Min	Mix	Mean	Min	Max	Mean
Equilibrium moisture, %		9.9	19.8	14.4	12.3	24.7	19.8
Ash (D), %		5.2	24.9	15.8	3.3	24.9	13.9
Volatile matter (DAF), %		34.1	58.3	40.6	34.6	65.4	44.0
Fixed carbon (DAF), %		41.6	65.8	59.3	34.5	65.3	55.9
Calorific value (MMMF),	kJ/kg	22653	27538	25479	20204	27130	23048
	kcal/kg	5412	6580	6088	4827	6481	5506
Calorific value (DAF),	kJ/kg	28084	31599	29926	27433	32769	29315
	kcal/kg	6710	7550	7150	6554	7829	7003
Carbon (DAF), %		67.10	78.70	75.63	65.73	83.98	74.49
Hydrogen (DAF), %		3.20	6.34	4.63	4.28	5.94	5.05
Nitrogen (DAF), %		0.89	1.62	1.16	0.88	1.89	1.49
Sulphur (D), %		0.15	1.79	0.39	0.03	2.80	0.47
(95% confidence level)			(0.36-0.41)			(0.44-0.50)	
Oxygen (DAF), %		15.87	23.79	18.17	14.93	26.17	18.32

		Belly River Group			Wapiti Formation		
		Min	Mix	Mean	Min	Max	Mean
Equilibrium moisture, %		8.5	26.9	14.0	n/a	n/a	n/a
Ash (D), %		6.9	24.7	16.6	4.5	24.6	11.5
Volatile matter (DAF), %		39.6	48.4	44.6	39.9	49.2	44.2
Fixed carbon (DAF), %		51.5	60.7	55.3	50.7	60.0	55.7
Calorific value (MMMF),	kJ/kg	20104	29356	26065	n/a	n/a	n/a
	kcal/kg	4803	7013	6227	n/a	n/a	n/a
Calorific value (DAF),	kJ/kg	26465	32094	29226	26349	32394	28345
	kcal/kg	6322	7667	6982	6295	7739	6772
Carbon (DAF), %		71.77	76.47	74.72	68.26	73.82	71.87
Hydrogen (DAF), %		4.44	5.75	5.08	4.61	4.96	4.83
Nitrogen (DAF), %		1.32	1.94	1.89	1.34	1.61	1.48
Sulphur (D), %		0.33	1.19	0.66	0.11	0.95	0.32
(95% confidence level)			(0.60-0.72)			(0.29-0.35)	
Oxygen (DAF), %		14.41	16.29	15.57	19.53	25.44	21.50

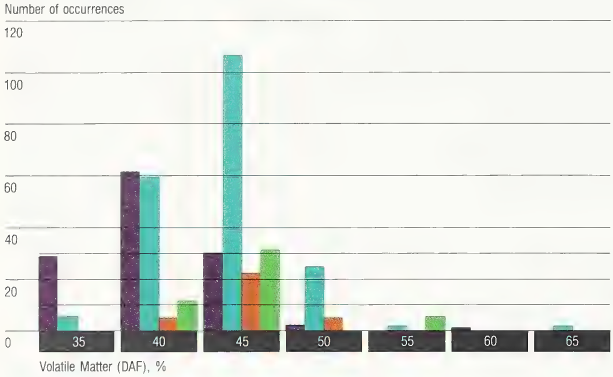
Source: Alberta Research Council

Plains Coals - Distribution of Properties

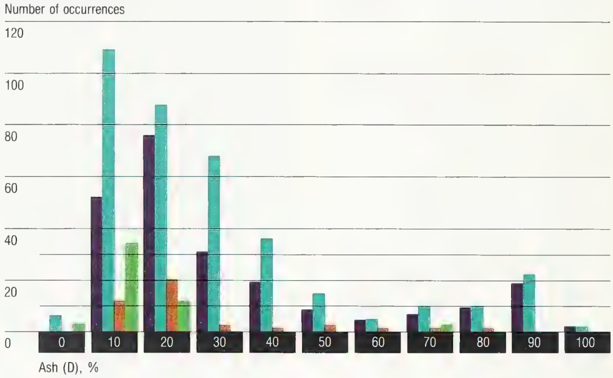
🟪 Scollard Member
🟦 Horseshoe Canyon Formation
🟧 Belly River Group
🟩 Wapiti Formation

Source: Alberta Research Council

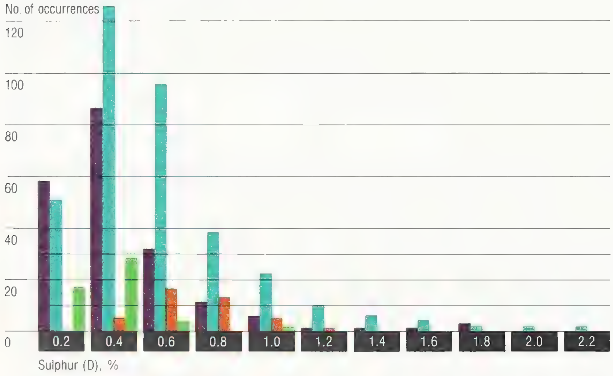
Distribution of Volatile Matter (dry ash-free basis) Percentages



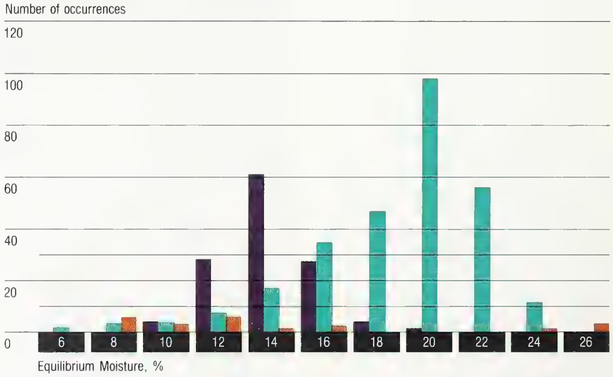
Distribution of Ash (dry basis) Percentages



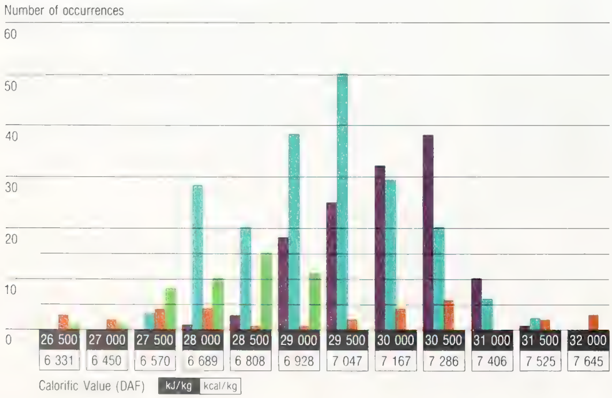
Distribution of Sulphur Percentages



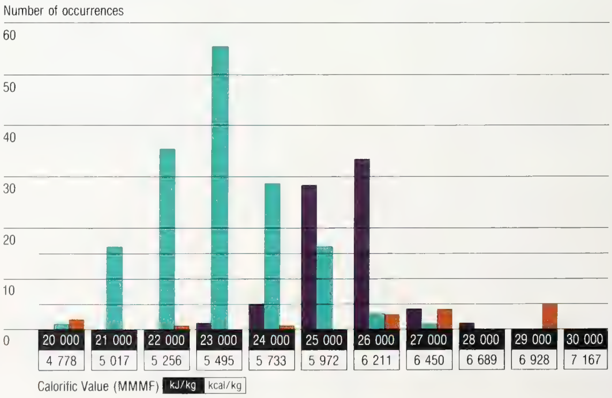
Distribution of Equilibrium Moisture Percentages



Distribution of Calorific Values (dry ash-free basis)



Distribution of Calorific Values (moist mineral matter-free basis)



Combustion

The Alberta Office of Coal Research and Technology has initiated several coal combustion studies in conjunction with the coal industry and in collaboration with end users in an effort to encourage knowledge sharing between producers and users. The more that is known about combustion characteristics, the more likely it is that coal sales can be made to those customers whose specific requirements closely match the properties of Alberta coals. Also, an understanding of coal combustion characteristics is critical for assessing the quality of upgraded coals.

Gasification

In anticipation of the important role that gasification technology is expected to play in the mid-1990s, several gasification research projects are currently assessing the suitability of Alberta coals for this application.

Liquefaction

The ability to convert coal into liquid fuels has been identified as a potential long-term strategic goal for Alberta's coal industry, particularly in view of the significant subbituminous resources available in the plains.

While prospects for operation of a commercial-scale coal liquefaction process during this century appear to be limited, the importance of this option is reflected in several research investigations already underway.

The potential value of the liquefaction option is that it can lead to sales of coal-derived fuels and may allow the sale of technology, and the coal it requires, to overseas customers. Meanwhile, co-processing of subbituminous coal and heavy oil or bitumen appears to offer significant advantages and may lead to introduction of this technology in the near future.

^
Petrography is used to establish relationships between the maceral content of coals and their suitability for conversion to liquid or gaseous fuels.

<
Coal conversion experiments are undertaken inside explosion containment cells at Alberta Research Council.

The Alberta Advantage

There are many advantages to using Alberta coals. They include:

- low sulphur content
- wide variety of quality products
- low production costs resulting from modern and innovative mining technology
- a skilled labor force
- stable and reliable producers who enjoy a record of good labor relations
- an excellent railway transportation system
- efficient coal terminals at Pacific tidewater
- a market-related research and development program, conducted co-operatively by industry and government to enhance the competitiveness of Alberta's coal industry and to develop coal-based products that meet customer requirements
- positive policies of a stable and supportive government
- no anticipated intervention by government in coal exports
- substantial in-place reserves of coal and long-term reliability of supply.

Appendix I

Major Alberta Coal Projects

Luscar Ltd.

Coal Valley Mine: Located south of Edson, the Coal Valley Mine is a joint venture of Luscar Ltd. (75%) and the Alberta Energy Company (25%) and is operated by Luscar Sterco (1977) Ltd. The mine supplies high volatile bituminous steam coal to Ontario Hydro and to the export market. The mine has a rated capacity of three million tonnes per year.

Luscar Mine: Located south of Hinton, the Luscar Mine is owned and operated by Cardinal River Coals Ltd. It is a joint venture of Luscar Ltd. (50%) and the Consolidation Coal Company of Canada Ltd. (50%). The mine produces medium volatile bituminous coking coal for the steel industry. Annual capacity is three million tonnes. In-place reserves are estimated to be in excess of 400 million tonnes of raw coal.

Paintearth and Diplomat Mines: Located near Forestburg, both mines produce subbituminous 'C' coal. They have a combined capacity of two million tonnes per year. The Paintearth Mine delivers coal to Alberta Power Limited's Battle River Generating Station, while the Diplomat Mine provides sized coal for various industrial and domestic customers.

Manalta Coal Ltd.

Gregg River Mine: This open-pit operation is located 35 km south of Hinton, on the eastern slopes of the Rocky Mountains. It is capable of producing 2.1 million tonnes per year of clean, medium volatile bituminous coal for coking purposes. The Gregg River Mine is operated by Gregg River Resources Ltd., a subsidiary of Manalta Coal Ltd., on behalf of a joint venture between Gregg River Coal Ltd. and seven Japanese companies.

Vesta Mine: The Vesta Mine supplies subbituminous 'C' steam coal for Alberta Power Limited's Battle River generating station, and is located north of Halkirk on the south side of the Battle River. The mine produces in excess of one million tonnes per year.

Montgomery Mine: This Manalta mine, located near the hamlet of Sheerness, produces coal for domestic purposes and power generation in Saskatchewan. Because of a delay in the commissioning of the Sheerness generating station, Montgomery's expansion will be delayed. The mine will supply approximately 1.5 million tonnes of coal per year to the new station.

McIntyre Mines Limited

McIntyre Mines Limited, through its wholly-owned subsidiary Smoky River Coal Limited, exports low volatile bituminous coking coal. The Smoky River operation in Grande Cache is capable of producing up to 2.2 million tonnes of coal per year from underground and surface mining. The mine site has proven reserves of 27 million tonnes that can be surface mined and another 42 million tonnes may be removed by underground mining. Another 38 million tonnes are regarded as probable. Major operating improvements have occurred at this mine during the past few years.

Obed Mountain Coal Company Limited

Obed Mountain Coal operates a mine in the foothills region having an annual production capacity of three million tonnes. The mine produces high volatile, bituminous steam coal for domestic and export markets. Recoverable reserves are estimated to be more than 100 million tonnes. The mine is owned jointly by Union Oil Company of Canada Limited and Norcen Energy Resources Limited.

TransAlta Utilities Corporation

Whitewood Mine: The Whitewood Mine is located on the north shore of Wabamun Lake. It is operated under contract by Fording Coal Ltd. The mine supplies approximately two million tonnes a year of subbituminous 'C' coal to the adjacent Wabamun generating station.

Highvale Mine: This is the largest coal mine in Canada, located on the south shore of Wabamun Lake about 65 km west of Edmonton. The mine supplies about 12 million tonnes of subbituminous 'C' steam coal a year to the adjacent Sundance and Keephills power generating stations. Manalta Coal Limited operates the mine under contract with TransAlta.

Appendix II

Coal Industry Contacts

Major Alberta Coal Producers

S,C,E Luscar Ltd.
1600 Oxford Tower
10235 - 101 Street
Edmonton, Alberta
T5J 3G1

Attention: Vice-President, Marketing-International

Telephone: (403) 420-5810
Telex: 037-2484

S,C,E Manalta Coal Ltd.
P.O. Box 2880
734 - 7 Avenue, S.W.
Calgary, Alberta
T2P 3P8

Attention: Vice-President,
Marketing and Business Development

Telephone: (403) 294-5355
Telex: 03-826840

C,E McIntyre Mines Limited
Three Calgary Place
14th Floor, 355 - 4 Avenue, S.W.
Calgary, Alberta
T2P 0J3

Attention: General Manager, Marketing

Telephone: (403) 267-4513
Telex: 03-825840

S,E Obed Mountain Coal Company Limited
P.O. Box 999
14th Floor, 335 - 8 Avenue, S.W.
Calgary, Alberta
T2P 2K6

Attention: Vice-President, Marketing and Transportation

Telephone: (403) 268-0176
Telex: 03-824592

S TransAlta Utilities Corporation
P.O. Box 1900
110 - 12 Avenue, S.W.
Calgary, Alberta
T2P 2M1

Attention: Vice-President, Planning

Telephone: (403) 267-7110
Telex: 03-826663

Association

The Coal Association of Canada
301, 1000 - 8 Avenue, S.W.
Calgary, Alberta
T2P 3M7

Telephone: (403) 262-1544
Telex: 03-827596

S = Steam
C = Coking
E = Export Contracts

Appendix III

Alberta Government Contacts

The Department of Energy administers and manages Alberta's energy resources. In relation to coal, the department administers Crown coal leases, collects royalties, formulates mineral policy, administers the Alberta/Canada Energy Resources Research Fund and provides support in various ways for the development of Alberta's coal resources. The department also operates the Alberta Office of Coal Research and Technology and employs the Coal Development Advisor.

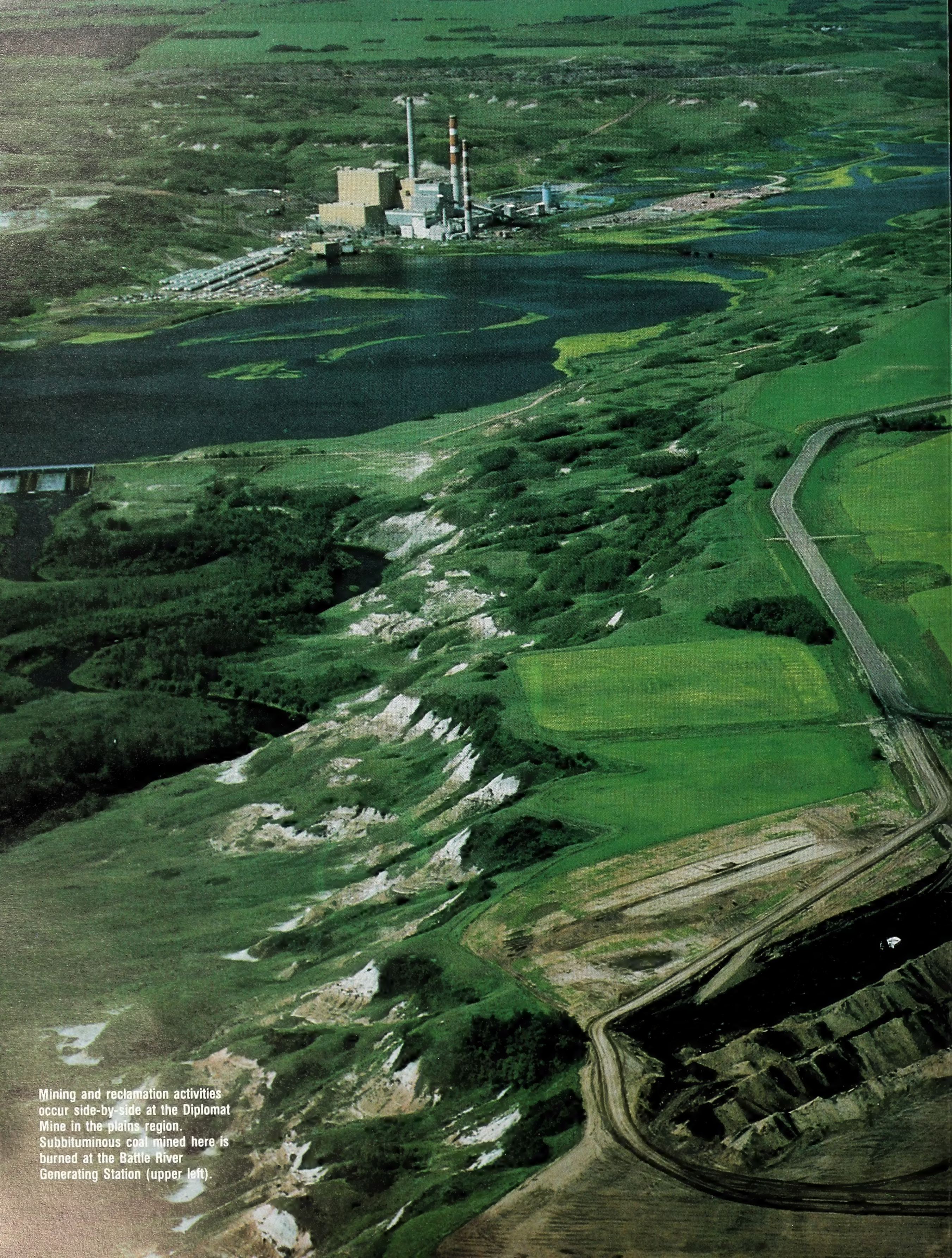
Contacts:

Chairman
Alberta Office of Coal Research and Technology
Alberta Department of Energy
2nd Floor, Pacific Plaza
10909 - Jasper Avenue
Edmonton, Alberta
T5J 3M8

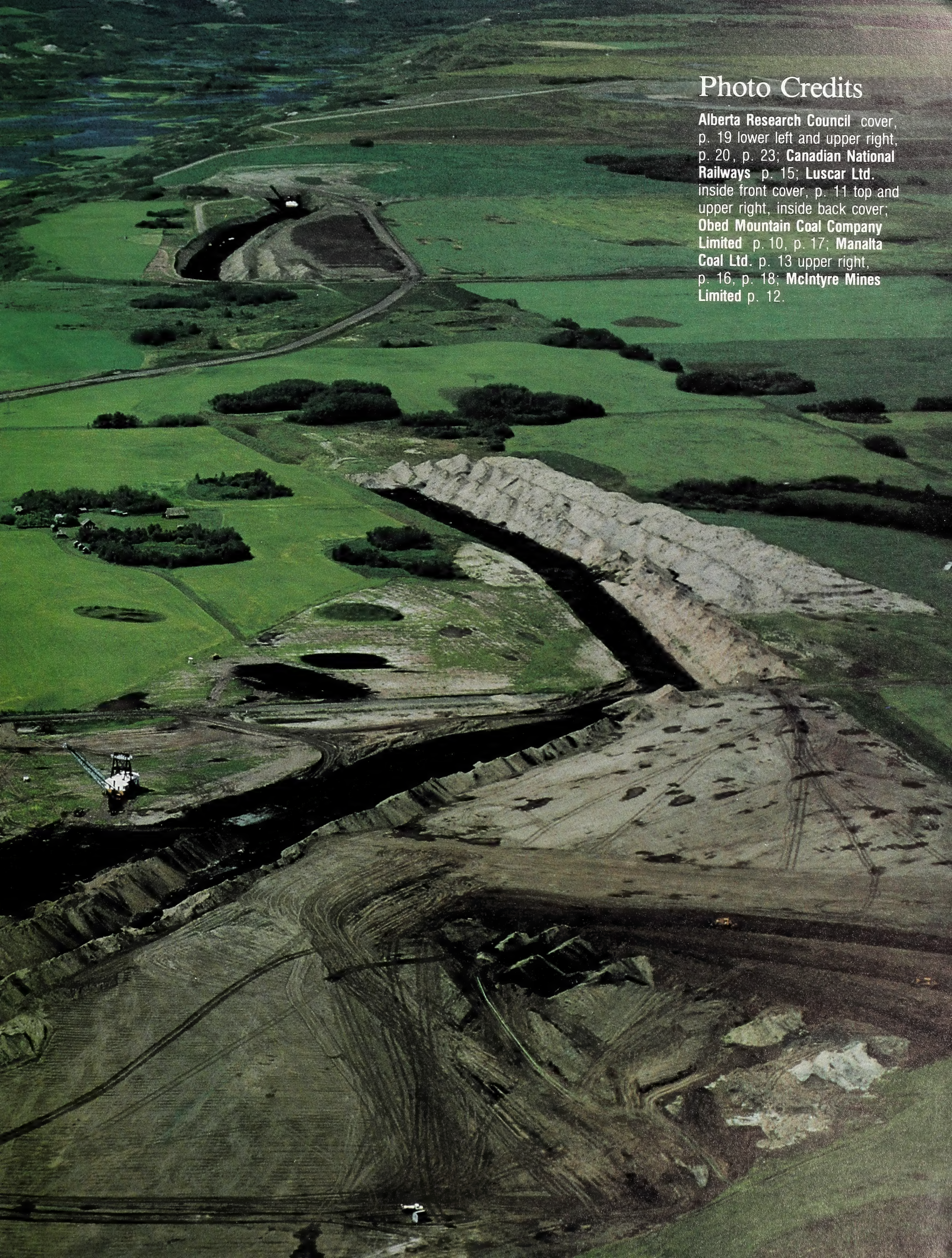
Telephone: (403) 427-8042
Telex: 037-3676

Coal Development Advisor
Alberta Department of Energy
2nd Floor, Pacific Plaza
10909 - Jasper Avenue
Edmonton, Alberta
T5J 3M8

Telephone: (403) 427-3490
Telex: 037-3676



Mining and reclamation activities occur side-by-side at the Diplomat Mine in the plains region. Subbituminous coal mined here is burned at the Battle River Generating Station (upper left).



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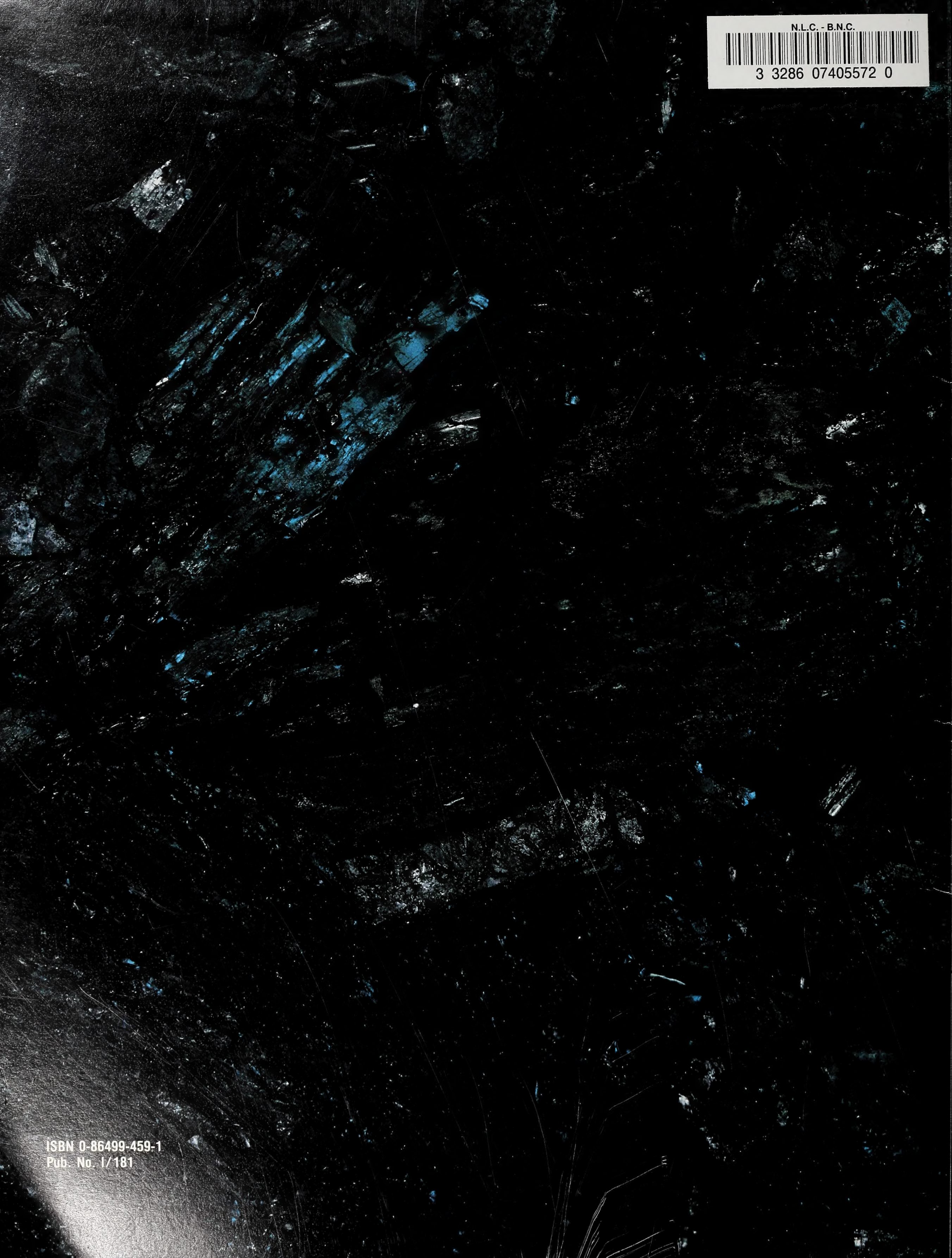
Alberta Research Council cover, p. 19 lower left and upper right, p. 20, p. 23; **Canadian National Railways** p. 15; **Luscar Ltd.** inside front cover, p. 11 top and upper right, inside back cover; **Obed Mountain Coal Company Limited** p. 10, p. 17; **Manalta Coal Ltd.** p. 13 upper right, p. 16, p. 18; **McIntyre Mines Limited** p. 12.



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